

JAPANESE

[JP,2000-249540,A]

CLAIMS DETAILED DESCRIPTION TECHNICAL FIELD PRIOR ART EFFECT OF THE INVENTION TECHNICAL PROBLEM MEANS DESCRIPTION OF DRAWINGS DRAWINGS

[Translation done.]

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- 2.\*\*\*\* shows the word which can not be translated.
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## CLAIMS

[Claim(s)]

[Claim 1]A form measuring apparatus of a roll which measures shape of a cylindrical device under test characterized by comprising the following.

A pivot means which rotates an axial center for said device under test as a center mostly.

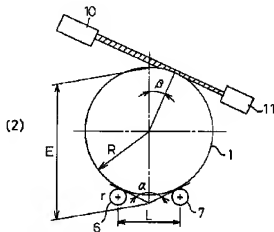
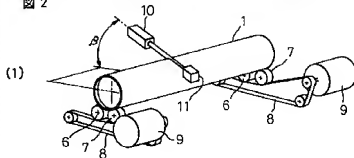
A rotation angle position detection means to detect a rotation angle position of said device under test.

The 1st tangent displacement detecting means that detects displacement of a tangent vertical to the 1st direction of an outside in a specified section of said device under test.

The 2nd tangent displacement detecting means that detects displacement of a tangent vertical to the 2nd direction of an outside in a specified section of said device under test, The 3rd tangent displacement detecting means that detects displacement of a tangent vertical to the 3rd direction of an outside in a specified section of said device under test, A calculating means which calculates contour shape in said specified section of said device under test from

Drawing selection **Drawing 2**

2



[Translation done.]

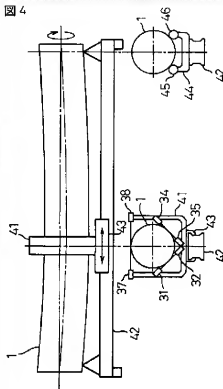
JAPANESE

[JP.2000-249540,A]

Drawing selection

Representative drawing

図 4



[Translation done.]

# CLAIMS DETAILED DESCRIPTION TECHNICAL FIELD PRIOR ART EFFECT OF THE INVENTION TECHNICAL PROBLEM MEANS DESCRIPTION OF DRAWINGS DRAWINGS

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## DETAILED DESCRIPTION

[Detailed Description of the Invention]

[0001]

[Field of the Invention] Especially this invention relates to the form measuring apparatus and measuring method of a roll by a V-block bend method about the form measuring apparatus and measuring method of a roll.

[0002]

[Description of the Prior Art] In order that it may be required widely that contour shape, such as deviation-from-circular-form shape of a cylindrical machine part, should be measured precisely and it may meet such a demand from the former, various kinds of methods are proposed and put in practical use. To what is widely used as a roundness measuring instrument, it rotates in support of a roll in a turntable, there is a device which detects surface displacement with a contact type or a noncontact displacement gage, measuring an angle of rotation, and it is called a radius method in order to measure a radial change on the basis of the center of rotation of a buck. There is an electric micrometer which detects displacement of the contactor which contacts on the surface of a device under test with a differential transformer etc. as a contact type displacement gauge, for example. There are an electric capacity type, a photosensor, etc. as a non-contact type displacement gauge. Although the contour shape of the section which is one measurement can be measured, if such measurement is performed in a section which changes a position in the direction of a cylindrical shaft, and is different in it, contour shape, such as cylindricity, can be measured. As for the measuring roundness machine of a radius method, it is indispensable that it is a rolling mechanism which realizes highly precise rotational accuracy in order to detect displacement of the normal line direction of a roll on the basis of mechanical rotation of measuring apparatus. Since a gap of the center of rotation of measuring apparatus and the center of a roll under test becomes an error of measurement, in order to maintain the fixed accuracy of measurement, it is necessary to perform an alignment hand control or automatically but, and an expensive device is needed, when are based on hand control and skill is based on an automatic.

[0003] A three-point method is known as a method of measuring the deviation-from-circular-form shape of a roll comparatively simple. (1) of drawing 1 is a figure for explaining a three-point method. In a three-point method, deviation-from-circular-form shape is computed by arranging the three displacement gages (here noncontact type) 3A - 3C in the three different directions, detecting the difference over the reference circle 2 of the surface position of the roll 1 of the portion, rotating a roll, and analyzing the result. It is necessary to coincide the detecting direction of three displacement gages on the intersection O and, the center of a roll and its center of rotation are arranged near the intersection O. Although a three-point method can be measured with a device

simpler than a radius method, in order to realize the required accuracy of measurement, appropriate accuracy is required for arrangement of a detector and a roll.

[0004]As mentioned above, in order to perform highly precise measurement, a highly precise rolling mechanism, the highly precise alignment work of a radius method and a three-point method, etc. are indispensable. Therefore, although it was suitable for measurement in a test chamber, a laboratory, etc., the roll in the state where the zipper was carried out to the machine tool by the work process was measured, and it was unsuitable for measurement in the yne process of measuring the roll under processing.

[0005]In order to process a highly precise roll efficiently, it is required to process it, measuring in a yne process, and it is requested that the contour shape of a roll is easily measured with high precision in a yne process. It is considered as the method of measuring the deviation-from-circular-form shape of a roll with sufficient accuracy simply, and the V-block bend method is known from the former. (2) of [drawing 1](#) is a figure for explaining a V-block bend method. In a V-block bend method, displacement of the portion after laid the roll 1 in V block 4, and it formed the displacement gage 5 which detects displacement of the upper portion, and it rotated, contacting the roll 1 to V block 4 and the displacement gage 5 detects is processed by harmonic analysis etc., and deviation-from-circular-form shape is measured. Although the number of detecting points is one like the above-mentioned radius method, since the position of the 2-way of the roll 1 is prescribed by V block 4, a highly precise rolling mechanism and highly precise alignment work of a V-block bend method are unnecessary, and setting out for measurement is easy for it.

[0006]Although the displacement gage was contacted in the upper part of the roll contacted by the V block in the V-block bend method, since the error was produced when the medial axis of the displacement gage had separated from the medial axis of the V block, the work which carries out alignment of the medial axis of a displacement gage is required, and it had become an obstacle of measurement in a yne process. Then, Yamada of the invention-in-this-application persons and willows are 26-32 pages per No. [ the ] (1995) with a [ "design engineering" ] of of volume [ 30th ]. The V-block bend method measuring roundness device which detects displacement of the tangent of the upper part of the roll laid in the V block with a V-block bend method using byway laser instead of detecting displacement of the portion on a roll is indicated. The displacement gage which detects displacement of the tangent of the roll of such a predetermined direction is called a tangent type displacement gage, and the displacement gage which detects the surface position of the normal line direction of the roll used by an above-mentioned radius method and three-point method will be called a normal type displacement gage. Since what is necessary is just to set up the direction of a laser beam correctly if it is a tangent type displacement gage, setting out becomes easy.

[0007]Since maintenance of a roll was easy for a V-block bend method compared with a three-point method and an operation was also easy, it was used widely, but in order to rotate a roll in the state where the V block was made to contact, contacting parts with the V block of a roll had a problem that a scratch (pickpocket) crack occurred. Then, Yamada of the invention-in-this-application persons and willows are 264-270 pages of the 7 No. (1997) with a [ "design engineering" ] of of volume [ 32nd ]. In support of a roll, it rotates on two rollers instead of a V block, and the V-block bend method measuring roundness device which detects displacement of the tangent of the upper part of a roll using byway laser is indicated.

[0008][Drawing 2](#) is a figure explaining this method.

(1) is a perspective view showing an entire configuration, and (2) is the figure seen from the direction of a cylindrical shaft.

The group of the two rollers 6 and 7 driven via the synchronous belt 8 by the synchronous motor 9 is arranged on 2-set both sides, and the roll 1 is laid there and it is made to rotate, as shown in [drawing 2](#). The tangent type displacement gage which comprises a group of the light sensing portion 11A which receives the light source part 10A which emits a parallel laser beam, and this laser beam, and detects that light volume is arranged so that a part of laser beam may be intercepted in the upper part of the roll 1. Since the light volume which the light sensing portion 11A receives according to the position in which the upper part of the roll 1 intercepts a part of laser beam changes, the position of the tangent of a roll parallel to a laser beam is detectable by asking for the blockage position and the relation of the output of the light sensing portion 11A beforehand. The group of the two rollers 6 and 7 also has the function similar to a V block. It will be called a false V block.

From a direction with a laser beam of a tangent type displacement gage vertical to the center line of a false V block, angle beta \*\*\*\*\* generalizes this, and shows, and it is for making

magnifying power into a suitable value.

[0009]

[Problem(s) to be Solved by the Invention]However, in the measuring device of drawing 2, the V block and measuring point which comprise the rollers 6 and 7 had a gap, and since it was not a perfect V block, there was a problem that the deviation-from-circular-form-shaped accuracy of measurement was insufficient. If it measures in a section which changes a position in the direction of a cylindrical shaft, and is different in it also with a V-block bend method, can measure three-dimensional contour shape, but. Since the V block serves as the supporting point of a roll, the position of a V block has not been freely arranged in the direction of a cylindrical shaft, but since a cylinder center was undetectable if sectional shape is measured in a portion without a V block, there was a problem that measurement of cylindricity could not be performed. For example, in the measuring device of drawing 2, since the installed position of the tangent position transducer has shifted from the supporting position of the rollers 6 and 7, and cannot say it as the state where it is supported with the V block but it is greatly influenced by the mechanical movement error accompanying rotation, a cylinder center is undetectable.

[0010]The hard metallic material etc. needed to be used for making accuracy of the rollers 6 and 7 high, and although there was little generating of a scratch flaw far compared with the time of using a V block, there was a problem that a crack could not be prevented thoroughly. This invention improves a V-block bend method in view of such a problem, the 1st purpose is to raise the accuracy of measurement, the 2nd purpose is enabling it to also measure cylindricity with a V-block bend method, and the 3rd purpose is to realize the V-block bend method which a crack does not generate.

[0011]

[Means for Solving the Problem]Drawing 3 is a figure showing a form measuring apparatus of a roll of this invention, and basic constitution of a measuring method, (1) shows an example which uses a normal type displacement gage of a contact type for detection of upside displacement by a tangent type displacement gage of a contact type to detection of a position of a contact surface of a virtual V block, and all (2) shows an example which uses a noncontact tangent type displacement gage.

[0012]As shown in drawing 3, a form measuring apparatus and a measuring method of a roll of this invention, By providing independently and detecting a position change of a tangent of a portion equivalent to a contact surface with a V block of the device under test 1, a mechanism turning around the device under test 1 searches for correctly a position of a contact surface of a virtual V block which contacts a roll virtually, and it amends noting that it is supported by V block in this position. The same analysis as a V-block bend method can be applied by this, and it can measure regardless of a supporting position of a roll, since what is necessary is just to be able to detect change of a roll of a tangent position of a predetermined direction moreover, a tangent type displacement gage can be used, and setting out can be performed easily. Since a center of rotation of a roll is detectable, cylindricity can be measured.

[0013]In (1) of drawing 3, as 1st [ which detects a position of a contact surface of a virtual V block ], and 2nd tangent type displacement gages, the plates 22 and 24 are formed in contactor of the contact type displacement gauges 21 and 23, such as an electric micrometer, and a displacement gage of a contact type contacted to the roll 1 is used. Since what is necessary is just to arrange the plates 22 and 24 to a contact surface of a virtual V block, and parallel in this invention, the contact type displacement gauges 21 and 23 are only arranged in the predetermined direction, and adjustment is easy in a relative position with the roll 1.

[0014]A noncontact tangent type displacement gage which similarly uses byway laser shown in drawing 2 as a 1st and 2nd tangent type displacement gage by (2) of drawing 3 is used. The light sensing portions 32 and 35 which receive the light source parts 31 and 34 which emit the parallel laser beams 33 and 36, and this laser beam, and detect that light volume are arranged so that a part of laser beam may be intercepted in the upper part of the roll 1. What is necessary is just to set up the direction of the laser beams 33 and 36 also in this case, and adjustment of a relative position with the roll 1 is easy.

[0015]About a top displacement gage which detects displacement of the upper part of a roll, as shown in (1) of drawing 3, even if it uses a normal type displacement gage which detects displacement of a normal line direction, as shown in (2) of drawing 3, a tangent type displacement gage which detects displacement of a tangent may be used. If displacement of a tangent is detected, the same tangent type displacement gage as detecting a position of a contact surface of a

virtual V block can be used, and since setting out is easy, it is suitable for measurement in a ync process.

[0016]In order to measure cylindricity, it is necessary to move a measuring cross section along with a cylindrical shaft, and a transportation device which carries out parallel translation of the 1st and 2nd tangent type displacement gages and top displacement gages along with a cylindrical shaft is established. A mechanism which lays a roll in a group of a roller as shown in [drawing 2](#), and it is made to rotate, and a mechanism which holds an end of a roll like a chuck mechanism of a machine tool, and is rotated are used for a rolling mechanism of the roll 1. A rotation angle position of a roll is computed from a pulse number of a pulse motor which drives a roller, or is detected using an encoder etc. which detect a rotation angle position of the axis of rotation of a machine tool.

[0017]When there is a possibility that a roll laid in a roller may slip with rotation, it is necessary to attach to a roll a member which has a rotation graduation, to make it rotate, and to carry out direct detection of the rotation angle position of a roll -- an optical or magnetic means detects a rotation graduation. In this case, since a rolling mechanism does not influence measuring accuracy, it is possible to also make it rotate with a roller etc. which provided elastic bodies, such as rubber, in the surface. Therefore, as shown in (2) of [drawing 3](#), if the 1st and 2nd tangent type displacement gages and top displacement gages are a noncontact type, a crack will not occur in a roll.

[0018]If the axis of rotation of a machine tool is made into a pivot means of a roll under test, attaching a roll to a machine tool, it cannot be overemphasized that there is no generating of a crack by measurement. It is usable in what uses laser used in an example of [drawing 2](#) as a noncontact tangent type displacement gage.

[0019]It is desirable that it can deal with a roll of a different diameter as a form measuring apparatus of a roll, and it is important practically for resetting when a diameter is moreover changed to be easy. As shown the roll 1 in [drawing 2](#), in supporting and rotating in a group of two rollers, when it sets the direction of a contact surface of a virtual V block as a tangent near a point of contact of a roll and a roller, even if a diameter of the roll 1 changes, change of a tangent position will be small.

[0020]A detection range is determined by path of a laser beam in a noncontact tangent type displacement gage which uses byway laser shown in [drawing 2](#). Therefore, if a tangent type displacement gage which uses byway laser shown in [drawing 2](#) is used, What what is used as 1st [ which detects a position of a contact surface of a virtual V block ], and 2nd tangent type displacement gages uses what has a small path of a laser beam, and is used as a top displacement gage uses what has a big path of a laser beam. If it is this, it can respond to a roll of a diameter of a wide range, without resetting. However, if a path of a laser beam becomes large, detecting accuracy of displacement will fall [ a tangent type displacement gage which uses byway laser shown in [drawing 2](#) ]. So, when using what has a small path of a laser beam also for a top displacement gage, it is desirable to establish a transportation device which moves a top displacement gage to a normal line direction of a device under test, and to enable it to correspond to a roll of various kinds of diameters. Although a laser beam of a big path can emit a tangent type displacement gage which uses byway laser to be used as a top displacement gage, it may be made to move an aperture made into a small path, since detecting accuracy will not fall if a path is restricted by an aperture. If a displacement detection range also with the 1st and 2nd wide tangent type displacement gages is required, it is desirable to form same mechanism.

[0021]

[Embodiment of the Invention] [Drawing 4](#) is omitted here, although it is a figure showing the composition of the form measuring apparatus of the roll of the 1st example of this invention and the computer etc. which constitute the data processing part which calculates contour shape from a detected tangent position are formed. As shown in [drawing 4](#), the rolling mechanism 44 which lays the roll 1 in the both ends of the linear guide 42, and is rotated is established. This rolling mechanism 44 is what formed the rollers 45 and 46 in both sides, and the laid roll 1 rotates it by rotating by driving sources, such as a pulse motor which is not illustrating the rollers 45 and 46. The layer of spring materials, such as rubber, is provided in the surface of the rollers 45 and 46, for example, and even if it rotates, the crack is kept from occurring on the surface of the roll 1. The outer diameter of the rollers 45 and 46 is measured correctly, and can detect the rotation of the rollers 45 and 46 by counting pulse numbers, such as a pulse motor, and since revolving speed is slow, Since the slip between the rollers 45 and 46 and the roll 1 is not produced at the time of rotation, the rotation of the roll 1 is detectable from the rotation of the rollers 45 and 46.

[0022]The V block test section 41 is provided with the following.

The 1st noncontact tangent type displacement gage that uses the laser which comprises the light source part 31 and the light sensing portion 32 the same with having been shown in (2) of drawing 3.

The 2nd noncontact tangent type displacement gage that comprises the light source part 34 and the light sensing portion 35.

The 3rd noncontact tangent type displacement gage that comprises the light source part 37 and the light sensing portion 38.

The light source parts 31, 34, and 37 and the light sensing portions 32, 35, and 28 are being fixed to the V block test section 41 by position relations. That is, the direction of the laser beam emitted from the light source parts 31, 34, and 37 is in a predetermined angular relationship. The V block test section 41 is laid in the movable carriage 43 along with the linear guide 42.

[0023]Drawing 5 is a figure explaining the principle of the noncontact tangent type displacement gage which uses laser. The collimating lens which makes the laser beam emitted from the laser diode and the laser diode a parallel laser beam is provided in the light source part 51. The thing which mode hopping etc. do not produce and which is stabilized and oscillated is used, and feedback control of the laser diode is carried out so that the laser beam of fixed intensity may always be outputted. Since the laser beam emitted from the laser diode since the section of the waveguide of a laser diode was detailed spreads greatly due to diffraction, a collimated beam is used with a collimating lens. Photo detectors which condense the laser beam which entered, such as a condenser and a photo-diode, are provided in the light sensing portion 52.

[0024]The light source part 51 and the light sensing portion 52 are arranged like drawing 5. If the edge 54 is moved to a sliding direction and a part of laser beam is intercepted in this state, the light volume of the laser beam received by the light sensing portion 52 will change. Since light income is simply fluctuated according to the position of the edge 54, if the position of the edge 54 and the correlation of light income are measured beforehand, the position of the edge 54 will become clear according to light income. Although it is also possible to consider that a laser beam is a Gaussian beam and to draw the position of the edge 54 and the correlation of light income theoretically, It is desirable to carry out roll arrangement so that a laser beam may be intercepted, to memorize change of light income when changing the position of a roll, and to search for the position of a roll and the correlation of light income in the stage actually arranged to the V block test section 41.

[0025]Even if the edge 54 moves in parallel with the direction of a laser beam so that clearly also from drawing 5, light income hardly changes. What is detected is change of the position of the tangent of a roll parallel to a laser beam, and since change of the position of a tangent is detected from change of light income when it initializes, the surface of a roll should just intercept a part of laser beam. Therefore, measurement is possible if a part of laser beam of the 1st to 3rd noncontact tangent type displacement gage arranged at the V block test section 41 is a range intercepted with the roll 1.

[0026]As a noncontact tangent type displacement gage which uses laser, A thin laser beam is scanned by a polygon mirror other than the method which detects change of the above light income, etc.. The photodetector which detects the scanned laser beam synchronizing with a scan is formed, there are a method etc. which arrange so that the surface of a roll may be located in a scanning zone, and detect the surface position of a roll from the detection timing of a photodetector, and the thing of such a method can also be used.

[0027]Next, although the measurement principle and data processing of sectional shape of a roll by the virtual V-block bend method of this invention are explained with reference to drawing 6, the case where it is presupposed that there is the usual V block instead of a virtual block first is explained before that. The roll 1 is laid in V block 4 of the angle  $\alpha$ , and (1) of drawing 6 shows the case where it measures with the 3rd noncontact tangent type displacement gage using the laser which comprises the light source part 37 and the light sensing portion 38 in the position of an upside tangent. The laser beam 39 is taken as an angle  $\beta$  \*\*\*\*\* thing from a direction vertical to the medial axis of V block 4. The center of the roll 1 is set to O, distance to the tangent detected from the tangent type displacement gage is made into  $r_U$ , distance to a point of contact with the left slope of V block 4 is made into  $r_L$ , and distance to a point of contact with a right slope is made into  $r_R$ . The distance  $y$  from the tangent detected with the tangent type displacement gage at this time to the valley of V block 4 (theta) is expressed with the following formula (1).

[0028]

[Equation 1]

$$y(\theta) = r_v + \frac{\cos \beta}{2 \sin \frac{\alpha}{2}} (r_L + r_R) + \frac{\sin \beta}{2 \cos \frac{\alpha}{2}} (r_L - r_R) \quad \cdots (1)$$

[0029] If the Fourier expansion into series of this is carried out and a formula is arranged, it will become like a formula (2).

[0030]

[Equation 2]

$$y(\theta) = \left[ 1 + \frac{\sin \beta}{\sin \frac{\alpha}{2}} \right] a_0 + \sum_{n=1}^{\infty} C_n \mu_{n, \alpha, \beta} \cos \left( t_n - \delta_{n, \alpha, \beta} \right) \quad \cdots (2)$$

ただし、

$$\mu_{n, \alpha, \beta} = \sqrt{(1 + l_{n, \alpha, \beta})^2 - f_{n, \alpha, \beta}^2} \quad , \quad \delta_{n, \alpha, \beta} = \tan^{-1} \left[ \frac{f_{n, \alpha, \beta}}{1 + l_{n, \alpha, \beta}} \right]$$

$$l_{n, \alpha, \beta} = \left[ \frac{\sin \beta \cos(U)}{\sin \frac{\alpha}{2}} \right] \cos n \beta + \left[ \frac{\cos \beta \sin(U)}{\cos \frac{\alpha}{2}} \right] \sin n \beta$$

$$f_{n, \alpha, \beta} = \left[ \frac{\sin \beta \cos(U)}{\sin \frac{\alpha}{2}} \right] \sin n \beta + \left[ \frac{\cos \beta \sin(U)}{\cos \frac{\alpha}{2}} \right] \cos n \beta$$

$$t_n = n \theta + \phi_n \quad U = n \frac{\pi + \alpha}{2}$$

[0031] At this time,  $a_0$  expresses the average radius of a section under test. The 2nd paragraph of the right-hand side expresses the size of an angular-frequency ingredient.  $\mu$  is called a scaling factor, and for every angular frequency, the measured deviation-from-circular-form shape will be expanded by a scaling factor, and will be measured. That is, since a scaling factor changes at the angle beta, according to a measuring object, the angle beta is set up suitably. The 1st noncontact tangent type displacement gage that comprises the light source part 31 and the light sensing portion 32 instead of V block 4 of (1) as shown in (2) of [drawing 6](#) in the case of a virtual V-block bend method. The 2nd noncontact tangent type displacement gage that comprises the light source part 34 and the light sensing portion 35 is arranged so that the laser beams 33 and 36 may become parallel to the slant face of V block 4, and distance  $r_L'$  and  $r_R'$  of a tangent from the center O are measured. Distance  $y'(\theta)$  from the tangent detected with the tangent type displacement gage of

the upper part at this time to the valley of a virtual V block is expressed with the following formula (3).

[0032]

[Equation 3]

$$y'(\theta) = r'_u + \frac{\cos \beta}{2 \sin \frac{\alpha}{2}} (r'_L + r'_R) + \frac{\sin \beta}{2 \cos \frac{\alpha}{2}} (r'_L - r'_R) \quad \cdots (3)$$

[0033] In a virtual V-block bend method, since the roll 1 is not supported with a V block but there is a supporting point (rollers 45 and 46) independently,  $r'_L$  and  $r'_R$  become the value which added the rotational error of  $\delta_{L1}$  and  $\delta_{R1}$  to  $r_L$  and  $r_R$ , respectively.  $r_{ij}$  is the same. Therefore, a formula (3) turns into the following formula (4).

[0034]

[Equation 4]

$$y'(\theta) = r_u + \frac{\cos \beta}{2 \sin \frac{\alpha}{2}} (r_L + \delta_{L1} + r_R + \delta_{R1}) + \frac{\sin \beta}{2 \cos \frac{\alpha}{2}} (r_L + \delta_{L1} - r_R - \delta_{R1}) \quad \cdots (4)$$

[0035] Since error  $\delta_{L1}$  and  $\delta_{R1}$  are detected with the 1st and 2nd noncontact tangent type displacement gages, respectively,  $y'(\theta)$  will be obtained if  $y'(\theta)$  is amended according to the following formula (5).

[0036]

[Equation 5]

$$y(\theta) = y'(\theta) - \frac{\cos \beta}{2 \sin \frac{\alpha}{2}} (\delta_{L1} + \delta_{R1}) - \frac{\sin \beta}{2 \cos \frac{\alpha}{2}} (\delta_{L1} - \delta_{R1}) \quad \cdots (5)$$

[0037] Thus, when a virtual V-block bend method is used, the harmonic-analysis processing which searches for sectional shape only by the same measurement result as a V-block bend method being obtained, and amending is also the same as the case of a V-block bend method. Here, the explanation about harmonic-analysis processing is omitted. Although the center position of the roll 1 is displaced by a virtual V-block bend method as mentioned above, since the 1st and 2nd noncontact tangent type displacement gages detect a point of contact with a virtual V block, a main position can be searched for.

[0038] In order to measure cylindricity, it is common to carry out the multiple measurement of the deviation-from-circular-form shape along with a cylinder medial axis, and to pile up and ask for them. In the form measuring apparatus of the roll of this example, since the deviation-from-circular-form shape of arbitrary sections can be measured and the position of the center O can moreover also be detected, cylindrical shape can be found by moving the V block test section 41 along with the linear guide 42, and measuring and piling up the deviation-from-circular-form shape of a section in two or more positions.

[0039] Here, measurement of cylindricity when a medial axis of the roll 1 has bent is explained. A x-y coordinate system used as a straightness standard of the linear guide 42 is considered to a measuring roundness section. As shown in [drawing 7](#), suppose that the direction of a laser beam of the 1st tangent type displacement gage was set up in the direction vertical to a direction angle A. Leaning to a x axis of a x-y coordinate system. When distance to a laser beam intercepted from the starting point of a x-y coordinate system is expressed with L (A), a laser beam intercepted is expressed with the following formula (6).

[0040]

$$y = \frac{L(A)}{\sin A} - \frac{x}{\tan A} \quad \cdots (6)$$

[0041] The direction of the laser beam of a tangent type displacement gage is immobilization, and

L (A) can be found from a detection value. The center of the deviation-from-circular-form shape of a roll is expressed with the polar coordinate system  $r(\theta)$  made into the starting point, and it is made for the straight line of  $\theta=0$  to become the X-axis and parallel. As the deviation-from-circular-form-shaped central point is shown in [drawing 7](#), it will be located on the line shown by a formula (7).

[0042]  
[Equation 7]

$$y = \frac{L(A) - r(A)}{\sin A} - \frac{x}{\tan A} \quad \dots (7)$$

[0043] Supposing similarly it sets up the direction of the laser beam of the 2nd tangent type displacement gage in the direction vertical to the direction angle B Leaning to the x axis of a x-y coordinate system, the deviation-from-circular-form-shaped central point will be similarly located on the line shown by a formula (8).

[0044]  
[Equation 8]

$$y = \frac{L(B) - r(B)}{\sin B} - \frac{x}{\tan B} \quad \dots (8)$$

[0045] A formula (9) will be obtained, if the formula (7) and (8) is allied and is solved, since the deviation-from-circular-form-shaped central point is an intersection of the straight line expressed with the formula (7) and (8). Thereby, the coordinates of the central point of the deviation-from-circular-form shape in a x-y coordinate system can be found.

[0046]  
[Equation 9]

$$(x, y) = \left\{ \frac{\frac{\tan A}{\cos B} (L(B) - r(B)) - \frac{\tan B}{\cos A} (L(A) - r(A))}{\tan A - \tan B}, \frac{\frac{L(A) - r(A)}{\cos A} - \frac{L(B) - r(B)}{\cos B}}{\tan A - \tan B} \right\} \quad \dots (9)$$

[0047] The V block test section 41 is moved along with the linear guide 42, coordinates of the deviation-from-circular-form (changing z shaft orientations)-shaped central point are searched for, and if they are piled up, an axial center of a roll can be found. Although the above-mentioned example explained an example which measures deviation-from-circular-form shape and cylindricity of a roll of a certain diameter, As for a diameter of a roll which can be measured being restricted as a form measuring apparatus of a roll, it is desirable that a roll of a diameter of the widest desirable possible range can be measured by the smallest possible resetting. Hereafter, a modification according to such a demand is explained. [Drawing 8](#) shows the state where roll 1-A and 1-B of a diameter which are different on the rollers 45 and 46 which support the roll 1 were laid. If the laser beam 36 of the 2nd tangent type displacement gage is set up in the direction like a graphic display, a tangent of this direction of the roll 1A of a small diameter will be set to 36A, and a tangent of the roll 1B of a big diameter will be set to 36B. Therefore, in the case of the roll 1A of a small diameter, and the big roll 1B of a diameter, displacement of a position of a tangent of the direction of the laser beam 36 of the 2nd tangent type displacement gage is  $\Delta R$ , and it turns out that it is small. This is the same also about the 1st contact type displacement meter. On the other hand, it turns out that quantity  $\Delta U$  change of is done with a big position of a tangent of the upper part detected with the 3rd tangent type displacement gage.

[0048] Thus, when measuring without resetting a roll in which diameters differ, the 1st and 2nd tangent type displacement gages should just emit the laser beam 53 of a small path, as shown in (1) of [drawing 9](#). In a figure, the reference number 54 is a laser diode, 55 is a collimating lens, 56 is an aperture which regulates shape of a laser beam, 57 is a condenser, and 58 is photosensor. The aperture 56 does not need to be a circular opening and should just be a long and slender slit in a range which does not become problems, such as diffraction. If width of a slit is wide, resolution of the direction of a cylindrical shaft will fall.

[0049] On the other hand, the 3rd tangent type displacement gage needs to emit the laser beam 53 of a big path, as shown in (2) of [drawing 9](#). If it is this, the range of a diameter of a roll which can

be measured without resetting will become large. However, a tangent type displacement gage which uses laser shown in (1) of [drawing 9](#) and (2) has the problem that detecting accuracy of displacement falls, when a path of a laser beam becomes large. Then, as what has a small path of a laser beam is used also for the 3rd tangent type displacement gage and it is shown in (3) of [drawing 9](#), a light source part and a light sensing portion are accommodated in the same case 59, and a position is changed according to a diameter of a roll which measures the whole in accordance with the moving mechanism 60 as can move.

[0050]Or a big laser beam is emitted from the collimating lens 55, and an opening of the aperture 56 is made small and may enable it to move the member 59 holding the aperture 56 according to the moving mechanism 60, as shown in (4) of [drawing 9](#). [Drawing 10](#) is a figure showing composition of a form measuring apparatus of a roll of the 2nd example that measures shape of a roll in a yne process. A device of the 1st example is the composition only for measurement, and was rotating in support of both ends of the roll 1 with a roller. In the 2nd example, the zipper of the roll 1 is carried out to the axis of rotation 62 provided in the actuator 61 of the machine tools 64, such as an engine lathe and a cylindrical grinder, and it rotates. At the time of processing, it is processed by moving the member turning 65 which formed a byte, an emery wheel stone, etc. along with the movable carriage 63 parallel to an axial center of the roll 1. In the 2nd example, the same V block test section 41 as the 1st example shown in member turning by [drawing 4](#) is attached to the member turning 65, and shape of the roll 1 is measured. A measuring method is the same as the 1st example.

[0051]With the 2nd example, it is measurable, without removing shape of the roll 1 under processing from the axis of rotation 62. Although member turning which formed a byte, an emery wheel stone, etc., and member turning which attached the V block test section 41 are exchanged and used in [drawing 10](#), It is also possible to provide both member turning which formed a byte, an emery wheel stone, etc. in the movable carriage 63, and member turning which attached the V block test section 41, and to measure during processing.

[0052]Although an example of this invention was described above, it is usable and noncontact types other than a optical type which used laser as 1st and 2nd tangent type displacement gages may also use a thing of a normal type as the 3rd displacement gage. Since a thing of a contact type may be used as the 1st to 3rd displacement gage, a displacement gage only detects displacement or displacement of a tangent even in this case and it is not necessary to rotate a roll with a displacement gage, a crack is able to make contact pressure small and to keep also from arising.

[0053]

[Effect of the Invention]According to this invention, as explained above, sectional shape can be measured now with high precision by easy processing like a V-block bend method, and since setting out for measurement as well as a V-block bend method is easy, it is applicable also to measurement in a yne process. Since the position of a measuring cross section is not regulated by a V block, either, the sectional shape in arbitrary cross section positions can be measured, and cylindrical shape can also be measured now by connecting these.

[0054]Even if unlike a V-block bend method a roll is supported by a member with elasticity since the flexibility of support of a roll is high, or it supports a roll by the rolling mechanism which is not enough as for rotational accuracy, high-precision measurement is attained. If a noncontact type is used as a displacement gage, a crack will not be produced in a roll.

[Translation done.]

displacement of a tangent vertical to said the 1st to 3rd direction that said the 1st to 3rd tangent displacement detecting means detected, and a rotation angle position of said device under test which said rotation angle position detection means detected.

[Claim 2]A form measuring apparatus of a roll provided with a transportation device which is a form measuring apparatus of the roll according to claim 1, and carries out parallel translation along with an axial center of said device under test by making said the 1st to 3rd tangent displacement detecting means into one.

[Claim 3]A form measuring apparatus of a roll which is a form measuring apparatus of the roll according to claim 1 or 2, and is a noncontact type which detects the amount of displacement of a tangent of said device under test without said the 1st to 3rd tangent displacement detecting means contacting the surface of said device under test.

[Claim 4]Are a form measuring apparatus of the roll according to claim 3, and said the 1st to 3rd tangent displacement detecting means, Said laser beam is received with a laser light source which emits a parallel laser beam, A form measuring apparatus of a roll which is provided with a photodetector which outputs a signal corresponding to said laser beam which received light, arranges said device under test so that said a part of laser beam may be intercepted, and detects a tangent position of an outside of said device under test from an output signal of said photodetector.

[Claim 5]A form measuring apparatus of a roll turning around said device under test which it is a form measuring apparatus of the roll according to claim 4, and said pivot means is a group of at least 1 set of two rollers, and was supported by rotating this roller.

[Claim 6]A form measuring apparatus of a roll which is a form measuring apparatus of the roll according to claim 5, and is arranged so that, as for the said 1st and 2nd tangent displacement detecting means, said laser beam may pass through near a point of contact with said device under test of said two rollers.

[Claim 7]Are a form measuring apparatus of the roll according to claim 6, and said laser beam which said laser light source of the said 1st and 2nd tangent displacement detecting means emits has narrow width, A form measuring apparatus of a roll wide [ said laser beam which said laser light source of said 3rd tangent displacement detecting means emits ] compared with the said 1st and 2nd tangent displacement detecting means.

[Claim 8]A form measuring apparatus of a roll whose arrangement of the said 1st and 2nd tangent displacement

detecting means it is a form measuring apparatus of the roll according to claim 6, and it has a transportation device which moves said 3rd tangent displacement detecting means to a normal line direction of said device under test, and is immobilization.

[Claim 9] A form measuring apparatus of the roll according to claim 6 characterized by comprising the following. Said laser beam which said laser beam which said laser light source of the said 1st and 2nd tangent displacement detecting means emits has narrow width, and said laser light source of said 3rd tangent displacement detecting means emits. An aperture which intercepts selectively said laser beam to which it is wide compared with the said 1st and 2nd tangent displacement detecting means, and said laser light source emits said 3rd tangent displacement detecting means. A transportation device which moves this aperture to a normal line direction of said device under test.

[Claim 10] A form measuring apparatus of a roll which is a form measuring apparatus of the roll according to claim 4, and is the axis of rotation of a machine tool which said pivot means carries out the zipper of said device under test for processing, and rotates.

[Claim 11] A form measuring apparatus of a roll in which it is a form measuring apparatus of the roll according to claim 10, and said rotation angle position detection means is a rotation angle position detector of the axis of rotation of said machine tool.

[Claim 12] A form measuring apparatus of a roll provided with a transportation device which is a form measuring apparatus of the roll according to claim 4, and moves said the 1st to 3rd tangent displacement detecting means to a normal line direction of said device under test, respectively.

[Claim 13] A form measuring apparatus of the roll according to claim 4 characterized by comprising the following. An aperture which intercepts selectively said laser beam to which said laser light source emits said the 1st to 3rd tangent displacement detecting means.

A transportation device which moves this aperture to a normal line direction of said device under test.

[Claim 14] A form measuring apparatus of a roll which measures shape of a cylindrical device under test characterized by comprising the following.

A pivot means which rotates an axial center for said device under test as a center mostly.

A rotation angle position detection means to detect a rotation angle position of said device under test.

The 1st tangent displacement detecting means that detects

displacement of a tangent vertical to the 1st direction of an outside in a specified section of said device under test. The 2nd tangent displacement detecting means that detects displacement of a tangent vertical to the 2nd direction of an outside in a specified section of said device under test, A displacement detecting means which detects displacement of the 3rd direction of an outside in a specified section of said device under test, A rotation angle position of said device under test which said rotation angle position detection means detected, A calculating means which calculates contour shape in said specified section of said device under test from displacement of a tangent vertical to said 1st and 2nd directions that the said 1st and 2nd tangent displacement detecting means detected, and displacement of said 3rd direction that said displacement detecting means detected.

[Claim 15] A shape measurement method of a roll which measures shape of a cylindrical device under test characterized by comprising the following.

A process which rotates an axial center for said device under test as a center mostly.

A process of detecting a rotation angle position of said device under test.

A process of detecting displacement of a tangent vertical to the 1st direction of an outside in a specified section of said device under test.

A process of detecting displacement of a tangent vertical to the 2nd direction of an outside in a specified section of said device under test, A process of calculating contour shape in said specified section of said device under test from a process of detecting displacement of a tangent vertical to the 3rd direction of an outside in a specified section of said device under test, a rotation angle position of said device under test, and displacement of a tangent vertical to said the 1st to 3rd detected direction.

[Claim 16] A shape measurement method of a roll which is a shape measurement method of the roll according to claim 15, performs said process about two or more specified sections of said device under test, and measures change of contour shape of an axial center direction of said device under test.

[Claim 17] A shape measurement method of a roll in which it is a shape measurement method of the roll according to claim 15 or 16, and detection of displacement of a tangent vertical to said the 1st to 3rd direction is performed by a noncontact type.

[Claim 18] Are a shape measurement method of the roll

according to claim 17, and detection of displacement of a tangent vertical to said the 1st to 3rd direction, A shape measurement method of a roll which detects a tangent position of an outside of said device under test by arranging said device under test so that a part of parallel laser beam may be intercepted, and detecting said laser beam.

[Claim 19]A shape measurement method of a roll performed by rotating said device under test which it is a shape measurement method of the roll according to claim 18, and rotation of said device under test supported said device under test in a group of at least 1 set of two rollers, and rotated and supported this roller.

[Claim 20]A shape measurement method of a roll in which it is a shape measurement method of the roll according to claim 19, and said 1st and 2nd directions aim to go near the point of contact of said two rollers and said device under test from the center of said device under test.

[Claim 21]A shape measurement method of a roll performed by rotating the axis of rotation of a machine tool which is a shape measurement method of the roll according to claim 19, carries out the zipper of the rotation of said device under test for processing of said device under test, and rotates.

[Claim 22]A shape measurement method of a roll which measures shape of a cylindrical device under test characterized by comprising the following.

A process which rotates an axial center for said device under test as a center mostly.

A process of detecting a rotation angle position of said device under test.

A process of detecting displacement of a tangent vertical to the 1st direction of an outside in a specified section of said device under test.

A process of detecting displacement of a tangent vertical to the 2nd direction of an outside in a specified section of said device under test, A process of calculating contour shape in said specified section of said device under test from a process of detecting displacement of the 3rd direction of an outside in a specified section of said device under test, a rotation angle position of said device under test, displacement of a tangent vertical to said 1st and 2nd detected directions, and displacement of said 3rd detected direction.

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[Translation done.]

